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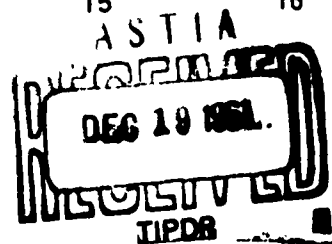
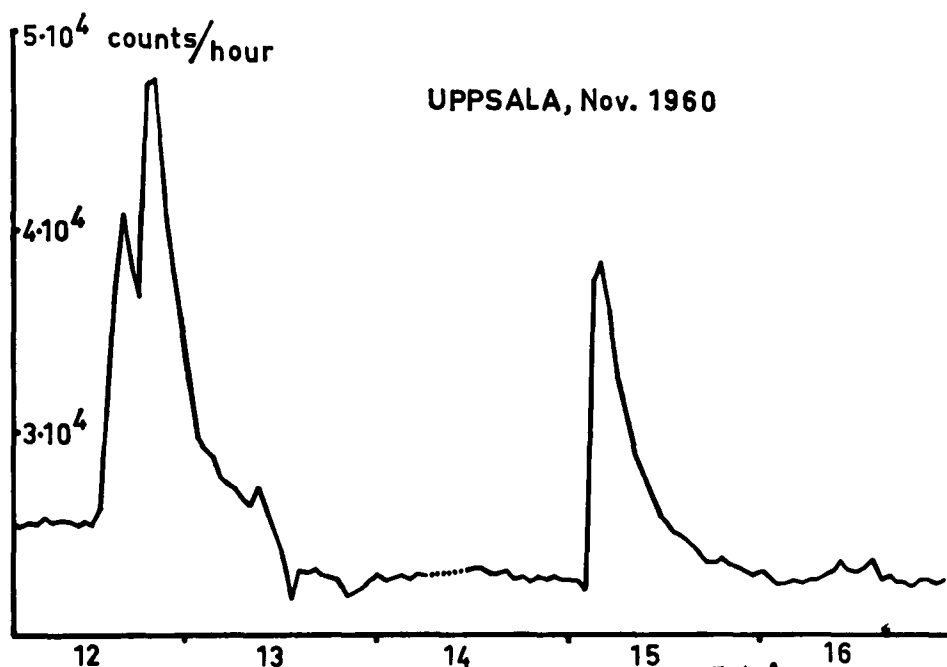
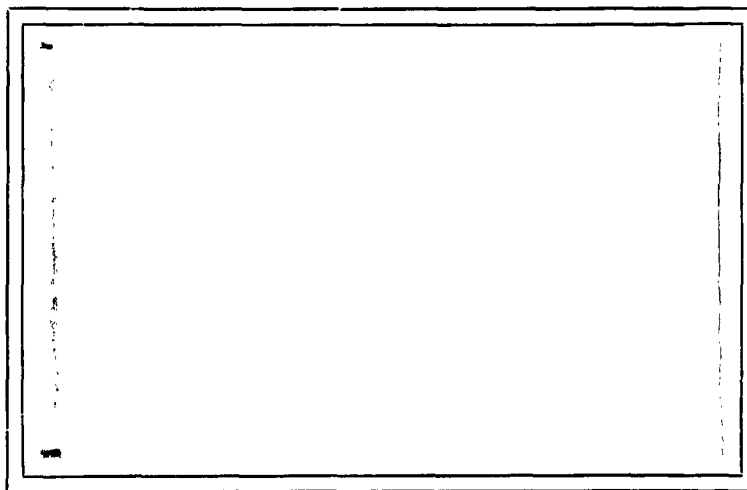
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COSMIC RAY INTENSITY VARIATIONS
DURING 1960

by

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Abstract

This note is a continuation of 12th Status Report and Technical Note No. 4. It contains tables and clock diagrams of the first and second harmonics of the daily variation during the calendar year 1960. Two more 12-monthly periods are included, one ending on 30 Apr. 1960 and the other on 31 Aug. 1960. The cosmic ray storms (Forbush decreases) during 1960 are displayed in diagrams over the intensity variations in per cent of a "normal" counting rate. The note contains also detailed diagrams of the solar flare effect on 4 May, 1960. The solar flare effects during November will be treated in a separate techn. (scientific) note.

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1. Introduction

The present Technical Note consists mainly of tables and diagrams concerning the meson and nucleon components recorded in Uppsala and Kiruna during 1960. It is essentially a continuation of the 12th Status Report. The equipment of the two recording stations was described in sec. 4 of the latter report. The only change has been in Kiruna where in May 1960 a third cubical standard telescope was added to the two previously in use.

The routine checking of the counter telescopes was described in sec. 5, 12th Status Report. Routine checking through the preliminary treatment of data was described in sec. 6. In the present instance all the corrections for atmospheric effects were made only according to eq. (1) in sec. 8 of 12th Status Report as there are too few aerological observations for an application of eq. (2). The accuracy of the recording instruments has been studied statistically by Eric Dyring. His study is presented in Technical Note No. 6.

The daily variation of the nucleonic component for the period September 1956 - December 1959 inclusive was treated separately in Technical Note No. 2. However, the 1960 nucleonic component data are included in the present technical note.

2. The daily variation

The harmonic analysis of the daily variation was described in sec. 9, 12th Status Report. The standard errors in the present note were calculated in the manner described in Technical Note No. 3. As before both the first and second harmonic have been calculated. The tables are arranged in the same way as in 12th Status Report. The mean daily variation was calculated for each sun rotation period. Table 1 contains the numbers of the sun rotation periods and the dates covered by each one of these periods.

Table 1

Key to the dates of the sun rotation periods

Sun rot. period	Date of start and finish	Sun rot. period	Date of start and finish
1731	29 Dec.1959-24 Jan.1960	1738	5 Jul.1960-31 Jul.1960
1732	25 Jun.1960-20 Feb.1960	1739	1 Aug.1960-27 Aug.1960
1733	21 Feb.1960-18 Mch 1960	1740	28 Aug.1960-23 Sep.1960
1734	19 Mch 1960-14 Apr.1960	1741	24 Sep.1960-20 Oct.1960
1735	15 Apr.1960-11 May 1960	1742	21 Oct.1960-16 Nov.1960
1736	12 May 1960-7 Jun.1960	1743	17 Nov.1960-13 Dec.1960
1737	8 Jun. 1960-4 Jul.1960	1744*	14 Dec.1960-9 Jan. 1961

*) Not included in Tables 2 - 15

Sec. 11 of 12th Status Report contains particulars concerning the preliminary treatment of the daily variation as well as the reasons for selecting 27 days for the short period means. It was also pointed out that most of the known or suspected seasonal variations will be eliminated in the yearly means.

The mean diurnal and semidiurnal variations during sun rotation periods are to be found in Tables 2 - 15. The corresponding mean values for 12-monthly periods are collected in Tables 16 and 17. Of the three series of 12-monthly periods one starts on the 1st of January, the second on the 1st of May and the third on the 1st of September (compare sec. 11 of 12th Status Report). In the tables as well as the figures the standard duplex telescopes are referred to as the zenith direction (Z).

Tables 18 and 19 contain a survey of days which have been excluded because of registration or power failures. The days displaying solar flare effects have been excluded from the 27-day means as well as the yearly means of the nucleon component. No solar flare effects were found in the records of the meson component. Ordinarily, Forbush decreases do not seriously affect either the 27-day means or the yearly means (Sandström and Lindgren, 1959).

Table 2

Nucleon Component, UPPSALA. Mean amplitudes for sun rotation periods in per cent of daily mean. Standard neutron pile monitor.

- a) Standard error from Poisson distribution of primary value
- b) Standard error from residuals after fitting 1st harmonic
- c) Standard error from residuals after fitting 1st + 2nd harmonic

Sun rot. period	Number of days	First harm.	Second harm.	Standard error		
				a)	b)	c)
1731	26	0.632	0.138	0.036	0.091	0.090
1732	25	0.314	0.079	0.036	0.073	0.078
1733	27	0.392	0.193	0.035	0.071	0.040
1734	26	0.392	0.285	0.036	0.103	0.055
1735	26	0.612	0.159	0.036	0.075	0.062
1736	26	0.410	0.225	0.036	0.119	0.108
1737	27	0.176	0.178	0.035	0.100	0.094
1738	27	0.262	0.191	0.035	0.066	0.029
1739	26	0.249	0.103	0.036	0.050	0.043
1740	26	0.428	0.143	0.036	0.066	0.055
1741	26	0.457	0.184	0.036	0.091	0.078
1742	24 *	0.402	0.079	0.037	0.092	0.100
1743	27	0.380	0.020	0.035	0.022	0.024

*) Three days excluded because of solar flare effects.

Table 3

Nucleon Component, UPPSALA, Mean amplitudes for sun rotation periods in per cent of daily mean. Standard neutron pile monitor.

- a) Standard error from Poisson distribution of primary value
b) Standard error from residuals after fitting 1st harmonic
c) Standard error from residuals after fitting 1st + 2nd harmonic

Sun rot. period	Number of days	First harmonic				Second harmonic		
		GMT	Standard error in min.			GMT	Standard error in min.	
			a)	b)	c)		a)	c)
1731	26	14 46	13	33	33	6 41	30	75
1732	25	12 28	26	53	57	10 52	52	113
1733	27	11 45	20	42	24	8 53	21	24
1734	26	13 27	21	60	32	8 7	14	22
1735	26	13 23	14	28	23	8 1	26	45
1736	26	14 32	20	67	60	8 3	18	55
1737	27	13 29	46	131	123	8 59	23	60
1738	27	14 55	31	58	26	7 24	21	18
1739	26	14 22	33	46	39	1 11	39	47
1740	26	14 45	19	36	29	6 41	29	44
1741	26	13 31	18	45	39	5 47	22	49
1742	24 *	12 3	21	52	57	9 49	54	146
1743	27	14 52	21	13	14	9 1	207	141

* Three days excluded because of solar flare effects.

Table 4

Zenith direction, UPPSALA. Mean amplitudes for sun rotation periods in per cent of daily mean. Duplex cubical telescopes, 10 cm lead equivalent.

- a) Standard error from Poisson distribution of primary value
b) Standard error from residuals after fitting 1st harmonic
c) Standard error from residuals after fitting 1st + 2nd harmonic

Sun rot. period	Number of days	First harm.	Second harm.	Standard error		
				a)	b)	c)
1731	26	0.247	0.041	0.018	0.021	0.018
1732	27	0.197	0.036	0.018	0.017	0.014
1733	27	0.215	0.032	0.018	0.013	0.010
1734	26	0.268	0.093	0.018	0.035	0.021
1735	27	0.110	0.013	0.018	0.024	0.027
1736	27	0.046	0.033	0.018	0.028	0.029
1737	25	0.108	0.036	0.019	0.016	0.013
1738	27	0.186	0.013	0.018	0.018	0.020
1739	26	0.242	0.078	0.018	0.029	0.018
1740	26	0.217	0.043	0.018	0.025	0.024
1741	27	0.214	0.014	0.018	0.014	0.015
1742	27	0.202	0.057	0.018	0.030	0.028
1743	23	0.192	0.027	0.019	0.022	0.023

Table 5

Zenith direction, UPPSALA. Phase of the first and second harmonics of the mean daily variation; sun rotation period. Duplex cubical telescope, 10 cm lead equivalent.

- a) Standard error from Poisson distribution of primary value
- b) Standard error from residuals after fitting 1st harmonic
- c) Standard error from residuals after fitting 1st + 2nd harmonic

Sun rot. period	Number of days	First harmonic				Second harmonic		
		GMT	Standard error in min.			GMT	Stand. error in min	
			a)	b)	c)		a)	c)
1731	26	15 55	17	19	17	10 57	51	51
1732	27	12 6	21	20	17	9 56	56	45
1733	27	11 52	19	14	10	9 45	63	35
1734	26	13 27	16	30	18	11 4	23	26
1735	27	12 58	37	50	56	9 14	165	249
1736	27	18 20	91	138	145	2 32	63	102
1737	25	14 52	40	35	28	10 26	60	42
1738	27	15 22	22	23	25	4 46	164	183
1739	26	15 25	17	28	17	8 34	27	26
1740	26	15 23	19	26	25	8 19	49	63
1741	27	14 36	19	15	17	3 48	143	122
1742	27	12 24	20	35	31	0 59	36	55
1743	23	14 55	23	26	27	7 27	83	98

Table 6

East direction, No filter, UPPSALA. Mean amplitudes for sun rotation periods in per cent of daily mean. Four channel telescope.

Sun rot. period	Number of days	First harm.	Second harm.	Standard error		
				a)	b)	c)
1731	25	0.217	0.079	0.024	0.033	0.024
1732	26	0.212	0.067	0.023	0.027	0.020
1733	27	0.276	0.069	0.023	0.031	0.026
1734	26	0.233	0.144	0.024	0.055	0.035
1735	27	0.204	0.075	0.023	0.033	0.026
1736	27	0.040	0.045	0.023	0.032	0.033
1737	26	0.153	0.070	0.024	0.029	0.022
1738	27	0.252	0.051	0.023	0.027	0.025
1739	27	0.315	0.068	0.023	0.033	0.028
1740	24	0.304	0.040	0.025	0.025	0.025
1741	27	0.260	0.067	0.023	0.034	0.030
1742	27	0.233	0.100	0.023	0.036	0.020
1743	27	0.264	0.109	0.023	0.037	0.015

Table 7

East direction, No filter, UPPSALA. Phase of the first and second harmonics of the mean daily variation; sun rotation period. Four channel telescope.

- a) Standard error from Poisson distribution of primary value
- b) Standard error from residuals after fitting 1st harmonic
- c) Standard error from residuals after fitting 1st + 2nd harmonic

Sun rot. period	Number of days	First harmonic				Second harmonic		
		GMT	Stand. error in min.			GMT	Stand. error in min.	
			a)	b)	c)		a)	c)
1731	25	14 42	26	35	26	1 12	35	35
1732	26	10 53	25	30	21	11 13	40	33
1733	27	13 31	19	26	21	9 32	38	43
1734	26	9 30	24	55	35	9 33	19	28
1735	27	11 34	26	37	29	11 7	35	39
1736	27	12 41	133	183	186	5 48	60	83
1737	26	14 15	36	44	33	8 8	39	36
1738	27	14 6	21	25	23	11 46	53	56
1739	27	14 45	17	24	20	10 18	39	47
1740	24	14 55	19	19	18	11 14	72	71
1741	27	13 30	20	30	27	10 59	40	52
1742	27	11 56	23	36	20	10 49	26	23
1743	27	13 1	20	32	13	10 47	24	15

Table 8

West direction, No filter, UPPSALA. Mean amplitude for sun rotation periods in per cent of daily mean. Four channel telescope.

- a) Standard error from Poisson distribution of primary value
- b) Standard error from residuals after fitting 1st harmonic
- c) Standard error from residuals after fitting 1st + 2nd harmonic

Sun rot. period	Number of days	First harm.	Second harm.	Standard error		
				a)	b)	c)
1731	22	0.142	0.067	0.026	0.028	0.021
1732	27	0.083	0.019	0.023	0.027	0.029
1733	27	0.147	0.017	0.023	0.020	0.022
1734	25	0.052	0.071	0.025	0.030	0.022
1735	27	0.068	0.028	0.023	0.017	0.016
1736	27	0.027	0.011	0.023	0.024	0.027
1737	23	0.057	0.079	0.025	0.031	0.020
1738	26	0.115	0.031	0.024	0.027	0.028
1739	27	0.369	0.019	0.023	0.026	0.019
1740	24	0.115	0.086	0.024	0.034	0.023
1741	27	0.109	0.019	0.023	0.029	0.032
1742	26	0.097	0.030	0.023	0.027	0.029
1743	27	0.103	0.078	0.023	0.033	0.024

Table 9

West direction, No filter, UPIBALA. Phase of the first and second harmonics of the mean daily variation; sun rotation period. Four channel telescope.

- a) Standard error from Poisson distribution of primary value
- b) Standard error from residuals after fitting 1st harmonic
- c) Standard error from residuals after fitting 1st + 2nd harmonic

c) Standard error from residuals after fitting first and second harmonics								
Sun rot. period	Number of days	GMT	First harmonic			GMT	Second harmonic	
			Stand.error in min.				a)	c)
			a)	b)	c)			
1731	22	19 43	41	46	34	10 5	44	36
1732	27	12 47	63	74	82	3 29	141	181
1733	27	9 43	36	32	35	4 7	152	146
1734	25	7 51	108	130	95	3 3	40	35
1735	27	18 16	77	56	53	5 18	95	65
1736	27	17 58	198	203	228	5 26	249	286
1737	23	18 10	102	124	80	7 34	36	29
1738	26	18 53	47	53	56	4 25	86	103
1739	27	17 32	77	86	95	8 57	142	176
1740	24	16 43	49	68	46	9 0	33	31
1741	27	16 46	48	60	67	7 21	140	195
1742	26	7 27	55	64	69	6 43	90	112
1743	27	14 22	51	73	54	8 40	34	36

Table 10

Zenith direction, KIRUNA. Mean amplitudes for sun rotation periods in per cent of daily mean. Duplex cubical telescopes. 10 cm lead equivalent.

- a) Standard error from Poisson distribution of primary value
- b) Standard error from residuals after fitting 1st harmonic
- c) Standard error from residuals after fitting 1st + 2nd harmonic

Sun rot. Period	Number of days	First harm.	Second harm.	Standard error		
				a)	b)	c)
1731	25	0.210	0.039	0.018	0.023	0.022
1732	27	0.138	0.030	0.017	0.019	0.019
1733	26	0.156	0.033	0.018	0.016	0.012
1734	26	0.180	0.032	0.018	0.025	0.026
1735	26	0.107	0.022	0.018	0.013	0.021
1736	21	0.031	0.024	0.019	0.019	0.032
1737	24	0.218	0.093	0.015	0.038	0.015
1738	22	0.153	0.036	0.016	0.026	0.021
1739	23	0.211	0.037	0.015	0.022	0.010
1740	12	0.045	0.019	0.021	0.029	0.028
1741	25	0.154	0.107	0.015	0.016	0.036
1742	24	0.081	0.031	0.015	0.019	0.027
1743	23	0.142	0.036	0.016	0.043	0.047

Table 11

Zenith direction, KIRUNA. Phase of the first and second harmonics of the mean daily variation; sun rotation period. Duplex cubical telescope, 10 cm lead equivalent.

Sun rot. period	Number of days	First harmonic				Second harmonic		
		GMT	Stand.error in min.			GMT	Stand.error in min.	
			a)	b)	c)		a)	c)
1731	25	16 26	20	25	24	10 54	52	63
1732	27	12 20	29	32	32	10 5	66	73
1733	26	12 6	26	24	18	2 59	53	37
1734	26	13 2	22	32	34	9 42	63	93
1735	26	13 41	38	71	50	2 55	25	33
1736	21	11 35	141	214	234	5 25	93	155
1737	24	18 17	16	61	58	9 55	18	64
1738	22	14 41	24	39	32	8 28	33	44
1739	23	16 12	17	23	21	4 0	49	62
1740	12	22 21	111	149	144	7 17	51	67
1741	25	18 10	22	69	54	2 13	16	39
1742	24	13 35	43	80	75	0 51	34	59
1743	23	22 20	25	69	75	5 51	50	150

Table 12

North direction, No filter, KIRUNA. Mean amplitudes for sun rotation periods in per cent of daily mean. Four channel telescope.

- a) Standard error from Poisson distribution of primary value
- b) Standard error from residuals after fitting 1st harmonic
- c) Standard error from residuals after fitting 1st + 2nd harmonic

Sun rot. period	Number of days	First harm.	Second harm.	Standard error		
				a)	b)	c)
1731	25	0.185	0.045	0.022	0.039	0.040
1732	26	0.078	0.040	0.022	0.032	0.034
1733	24	0.066	0.074	0.023	0.031	0.023
1734	26	0.120	0.054	0.022	0.024	0.018
1735	26	0.065	0.033	0.022	0.020	0.019
1736	27	0.111	0.040	0.022	0.030	0.031
1737	21	0.120	0.081	0.025	0.036	0.028
1738	23	0.187	0.030	0.024	0.029	0.031
1739	25	0.250	0.014	0.023	0.021	0.024
1740	24	0.136	0.045	0.023	0.033	0.033
1741	26	0.075	0.086	0.022	0.047	0.043
1742	25	0.133	0.052	0.022	0.036	0.036
1743	23	0.196	0.059	0.023	0.028	0.023

Table 13

North direction, No filter, KIRUNA. Phase of the first and second harmonics of the mean daily variation; sun rotation period. Four channel telescope.

- a) Standard error from Poisson distribution of primary value
- b) Standard error from residuals after fitting 1st harmonic
- c) Standard error from residuals after fitting 1st + 2nd harmonic

Sun rot. period	Number of days	First harmonic				Second harmonic		
		GMT	Stand.error in min.			GMT	Stand.error in min.	
			a)	b)	c)		a)	c)
1731	25	15 27	28	48	50	10 22	56	102
1732	26	8 5	64	95	99	10 30	62	95
1733	24	10 58	79	109	82	1 20	35	37
1734	26	11 43	42	45	35	5 57	46	38
1735	26	11 51	78	70	68	3 14	77	67
1736	27	12 55	45	62	63	10 39	62	87
1737	21	12 18	48	68	53	5 2	35	39
1738	23	12 57	29	35	38	8 45	90	116
1739	25	13 5	21	20	22	4 49	181	189
1740	24	13 40	39	55	56	7 26	59	84
1741	26	20 8	67	143	131	2 10	29	57
1742	25	10 35	38	61	61	9 13	49	78
1743	23	13 53	27	32	27	9 51	45	45

Table 14

South direction, No filter, KIRUNA. Mean amplitude for sun rotation periods in per cent of daily mean. Four channel telescope.

- a) Standard error from Poisson distribution of primary value
- b) Standard error from residuals after fitting 1st harmonic
- c) Standard error from residuals after fitting 1st + 2nd harmonic

Sun rot. period	Number of days	First harm.	Second harm.	Standard error		
				a)	b)	c)
1731	25	0.270	0.122	0.022	0.039	0.019
1732	26	0.122	0.087	0.022	0.040	0.033
1733	26	0.143	0.043	0.022	0.026	0.025
1734	21	0.185	0.115	0.025	0.044	0.028
1735	20	0.224	0.119	0.025	0.049	0.036
1736	27	0.120	0.121	0.022	0.043	0.022
1737	23	0.087	0.045	0.024	0.028	0.027
1738	23	0.225	0.081	0.024	0.030	0.018
1739	25	0.285	0.035	0.023	0.018	0.017
1740	24	0.276	0.026	0.023	0.021	0.022
1741	26	0.280	0.143	0.022	0.066	0.055
1742	25	0.152	0.064	0.023	0.047	0.048
1743	24	0.147	0.023	0.023	0.020	0.021

Table 15

South direction, No filter, KIRUNA. Phase of the first and second harmonics of the mean daily variation; sun rotation period. Four channel telescope.

- a) Standard error from Poisson distribution of primary value
- b) Standard error from residuals after fitting 1st harmonic
- c) Standard error from residuals after fitting 1st + 2nd harmonic

Sun rot. period	Number of days	First harmonic				Second harmonic		
		GMT	Stand.error in min.			GMT	Stand.error in min.	
			a)	b)	c)		a)	c)
1731	25	18 23	19	33	16	1 30	24	21
1732	26	15 55	41	76	63	1 20	29	44
1733	26	14 39	35	41	40	1 21	59	67
1734	21	15 45	30	55	34	1 20	24	28
1735	20	16 50	26	50	36	2 38	24	34
1736	27	19 9	42	83	43	2 37	21	21
1737	23	17 22	63	73	71	11 58	61	69
1738	23	15 23	24	31	18	11 32	34	25
1739	25	17 32	18	15	13	5 5	75	55
1740	24	17 44	19	18	18	1 24	101	96
1741	26	18 27	18	54	45	1 55	18	44
1742	25	12 36	34	71	73	2 51	41	87
1743	24	15 37	36	31	32	1 35	116	105

Key to Tables 16 - 17

- N_U = Uppsala, Nucleon Component
- Z_U = "- , Zenith Direction = Duplex Cubical Telescope, 10 cm lead equivalent
- E_U = "- , East Direction, Four channel telescope
- W_U = "- , West Direction, Four channel telescope
- Z_K = Kiruna, Zenith Direction = Duplex Cubical Telescope, 10 cm lead equivalent
- N_K = "- , North Direction, Four channel telescope
- S_K = "- , South Direction, Four channel telescope

Table 16

Yearly mean amplitudes of the daily variation.

- a) Standard error from Poisson distribution of primary value
- b) Standard error from residuals after fitting 1st harmonic
- c) Standard error from residuals after fitting 1st+2nd harmonic

Direction	Period	Number of days	First harm.	Second harm.	Standard error		
					a)	b)	c)
NM _U	1 May 1959-30 Apr.1960	351	0.363	0.088	0.010	0.038	0.030
	1 Sep.1959-31 Aug.1960	355	0.373	0.096	0.010	0.040	0.029
	Calendar year 1960	355	0.375	0.103	0.010	0.039	0.025
Z _U	1 May 1959-30 Apr.1960	347	0.182	0.019	0.005	0.010	0.009
	1 Sep.1959-31 Aug.1960	357	0.182	0.016	0.005	0.007	0.005
	Calendar year 1960	355	0.172	0.022	0.005	0.008	0.003
E _U	1 May 1959-30 Apr.1960	354	0.237	0.073	0.006	0.024	0.006
	1 Sep.1959-31 Aug.1960	361	0.213	0.044	0.006	0.016	0.008
	Calendar year 1960	358	0.209	0.057	0.006	0.019	0.006
W _U	1 May 1959-30 Apr.1960	339	0.066	0.012	0.007	0.009	0.009
	1 Sep.1959-31 Aug.1960	343	0.071	0.017	0.006	0.008	0.006
	Calendar year 1960	350	0.055	0.014	0.006	0.006	0.005
Z _K	1 May 1959-30 Apr.1960	333	0.128	0.011	0.005	0.008	0.008
	1 Sep.1959-31 Aug.1960	322	0.143	0.001	0.005	0.009	0.010
	Calendar year 1960	319	0.100	0.008	0.005	0.007	0.008
N _K	1 May 1959-30 Apr.1960	329	0.113	0.024	0.006	0.009	0.006
	1 Sep.1959-31 Aug.1960	343	0.122	0.008	0.006	0.009	0.010
	Calendar year 1960	335	0.113	0.006	0.006	0.008	0.008
S _K	1 May 1959-30 Apr.1960	323	0.145	0.049	0.006	0.016	0.006
	1 Sep.1959-31 Aug.1960	337	0.186	0.053	0.006	0.018	0.006
	Calendar year 1960	328	0.175	0.073	0.006	0.025	0.011

*) The three days in November displaying big solar flare effects have been excluded. These days are marked by an f in Table 18. If, instead, they are included the yearly means of the nucleon component will be

Calendar year 1960 358 0.344 0.149 0.010 0.052 0.024

Table 17

Yearly mean phases of the daily variation.

a) Standard error from Poisson distribution of primary value

b) Standard error from residuals after fitting 1st harmonic

c) Standard error from residuals after fitting 1st+2nd harmonic

Direction	Period	Number of days	First harmonic				Second harmonic		
			GMT	Stand.error in min.			GMT	Stand.error in min.	
				a)	b)	c)		a)	c)
NM _U	1 May 1959-30 Apr.1960	351	13 36	6	24	19	8 31	13	39
	1 Sep.1959-31 Aug.1960	355	14 7	6	25	18	8 3	12	35
	Calendar year 1960	355	13 40	6	24	15	8 24	11	28
Z _U	1 May 1959-30 Apr.1960	347	13 49	6	12	11	11 43	31	52
	1 Sep.1959-31 Aug.1960	357	14 18	6	9	7	11 16	35	39
	Calendar year 1960	355	14 7	7	10	4	10 28	26	17
E _U	1 May 1959-30 Apr.1960	354	13 21	6	23	6	10 57	10	10
	1 Sep.1959-31 Aug.1960	361	13 35	7	17	9	10 46	17	22
	Calendar year 1960	358	13 6	7	21	7	10 33	13	13
W _U	1 May 1959-30 Apr.1960	339	14 57	23	30	31	3 43	64	87
	1 Sep.1959-31 Aug.1960	343	16 33	21	25	21	4 57	45	44
	Calendar year 1960	350	15 9	27	26	20	7 23	52	39
Z _K	1 May 1959-30 Apr.1960	333	13 12	9	14	14	1 52	53	80
	1 Sep.1959-31 Aug.1960	322	14 54	8	15	17	11 49	478	1038
	Calendar year 1960	319	15 54	10	17	18	0 48	67	118
N _K	1 May 1959-30 Apr.1960	329	10 5	13	19	13	0 23	30	31
	1 Sep.1959-31 Aug.1960	343	12 38	11	17	18	10 24	86	136
	Calendar year 1960	335	12 52	12	16	17	10 9	126	173
S _K	1 May 1959-30 Apr.1960	323	15 53	10	26	9	1 44	15	13
	1 Sep.1959-31 Aug.1960	337	16 37	8	22	8	2 5	13	14
	Calendar year 1960	328	16 59	8	33	14	1 51	10	17

*) The three days in November displaying big solar flare effects have been excluded.

These days are marked by an f in Table 18. If, instead, they are included the yearly means of the nucleon component will be

Calendar year 1960 358 14 0 6 24 15 8 4 11 28

Table 18

Key to excluded days. UPPSALA 1960.

[illegible]

Table 19.
Key to excluded days. KIRUNA 1960.

Day	DUPILEX CUBICAL TELESCOPE												NORTH DIRECTION												SOUTH DIRECTION															
1																																								
2																																								
3																																								
4																																								
5																																								
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3. The first harmonic

The upper clock diagram in Fig. 1 displays the vectors for the first harmonics of the mean daily variation during the calendar year 1960. The circles mark the standard errors calculated from the residuals after fitting the first and second harmonics to the points of measurement (compare Technical Note No 3). All the directions from both stations have been entered into one and the same diagram for the purpose of comparison.

Four instruments have delivered records during four consecutive calendar years and three more instruments during three years. The vector sum diagrams are to be found in Fig. 2. Most of these diagrams reveal a phase shift towards a later time of maximum intensity. Exceptions are the east direction in Uppsala and the south direction in Kiruna. With the few 12-monthly periods as yet available it is difficult to tell if the irregularities are real or if they are to be ascribed to statistical fluctuations. Concerning the nucleon component there is no phase shift between 1959 and 1960. The amplitude displays a continuous increase during the last three years.

Returning to the clock diagrams in Fig. 1 we note that the phase difference between the north and south directions in Kiruna has decreased (compare Fig. 10, 12th Status Report, Part II). This indicates that there has been a change in the rigidity spectrum. The effective rigidity is now much lower than during the epoch 1957-59. According to a rough estimation from the experiments by Brunberg (1956) the effective rigidity is once again 25 GeV/c having been as high as 35 GeV/c in 1958 (sec. 15, 12th Status Report). However, the effective rigidity does not necessarily have to be the same for the two directions. It depends on the relative positions of the acceptance cones to be attributed to successive parts of the rigidity spectrum. This explains, also, that the phase change is accompanied by a change of the ratio between the amplitudes of the north and south directions at Kiruna.

Concerning the east and west directions at Uppsala there is no specific trend in the variations of the ratio between the amplitudes. That of the west direction is constantly much smaller than that of the east direction (Fig. 2). This was discussed in sec. 15, 12th Status Report.

4. The second harmonic

The clock diagrams of the second harmonics are to be found in the lower part of Fig. 1. The vector sum diagrams (corresponding to those of the first harmonics) are reproduced in Fig. 3.

As before (Fig. 22, 12th Status Report, Part II) the second harmonic of the west direction in Uppsala is insignificant. As concerns the east direction there is no doubt as to the existence of a second harmonic of the yearly mean daily variation. However, turning to the Kiruna records we find that for 1960 the second harmonic of the north direction has a very small amplitude and that for the south direction an amplitude making it important as compared to the standard error. This is a complete reversal from 1958 (Fig. 22, 12th Status Report, Part II). The vector sum diagrams in Fig. 3 reveal that this change actually took place during 1959. The variations as to phase and amplitude appear to depend on the direction of observation as well as on the coordinates of the station (Fig. 3). The second harmonic of the east direction in Uppsala is remarkably constant as to phase and amplitude.

Concerning the nucleon component it is very interesting to note that the amplitude of the second harmonic appears to increase rapidly. In 1958 it was less than the standard error. There is no doubt about its existence during 1960

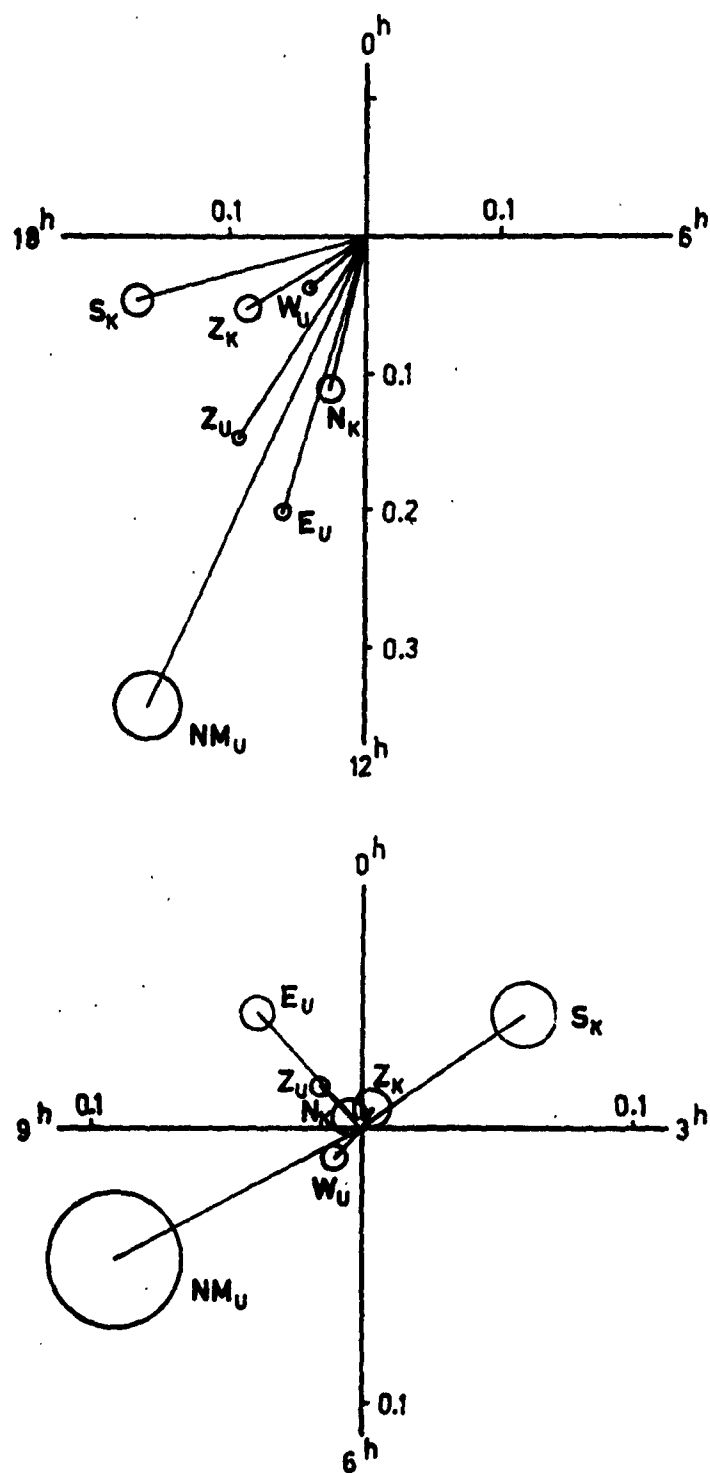


Fig. 1. Clock diagrams for the yearly means 1960. Upper diagram: first harmonics. Lower diagram: second harmonics.

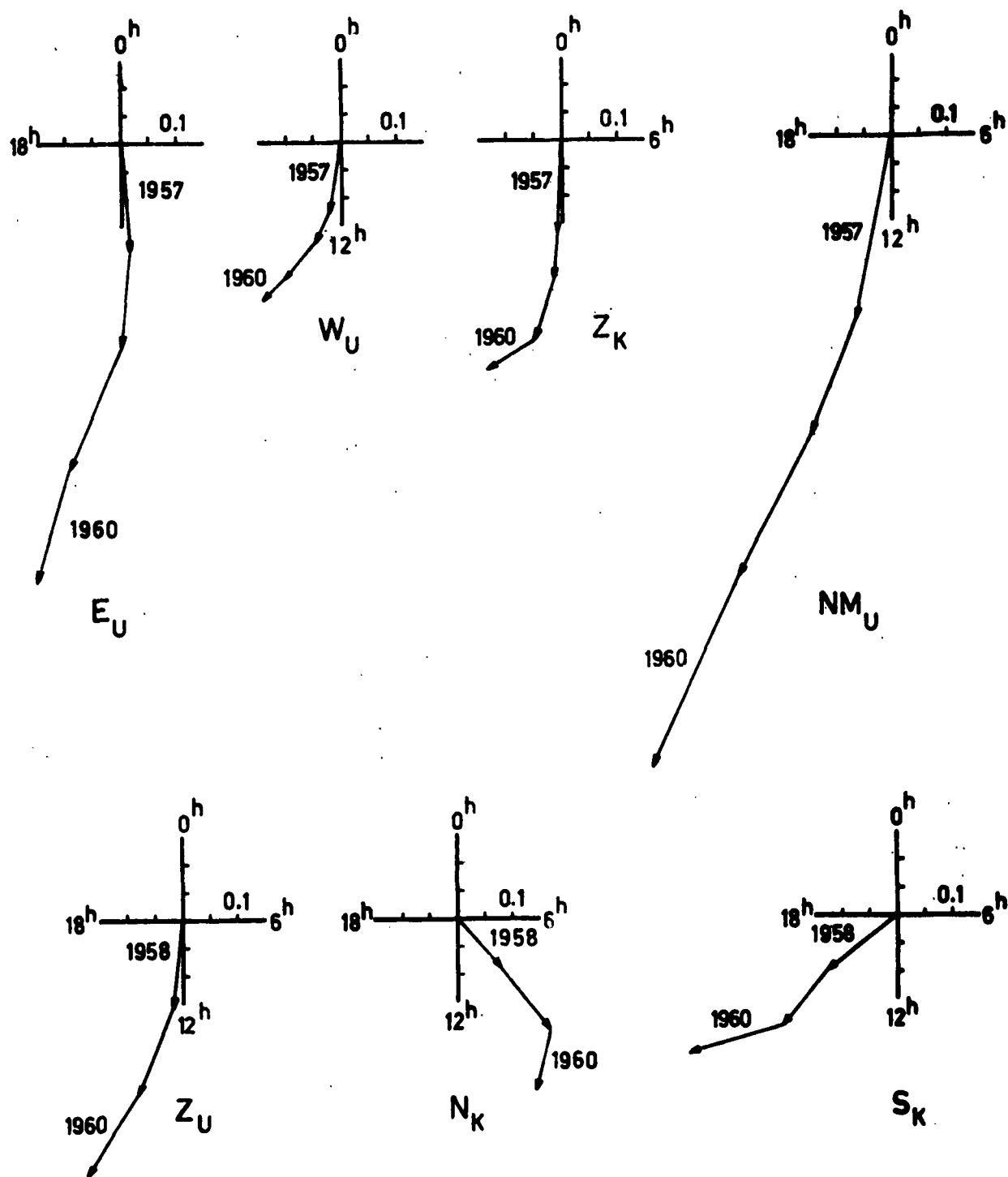


Fig. 2. Vector sum diagrams for the yearly means of the first harmonics.

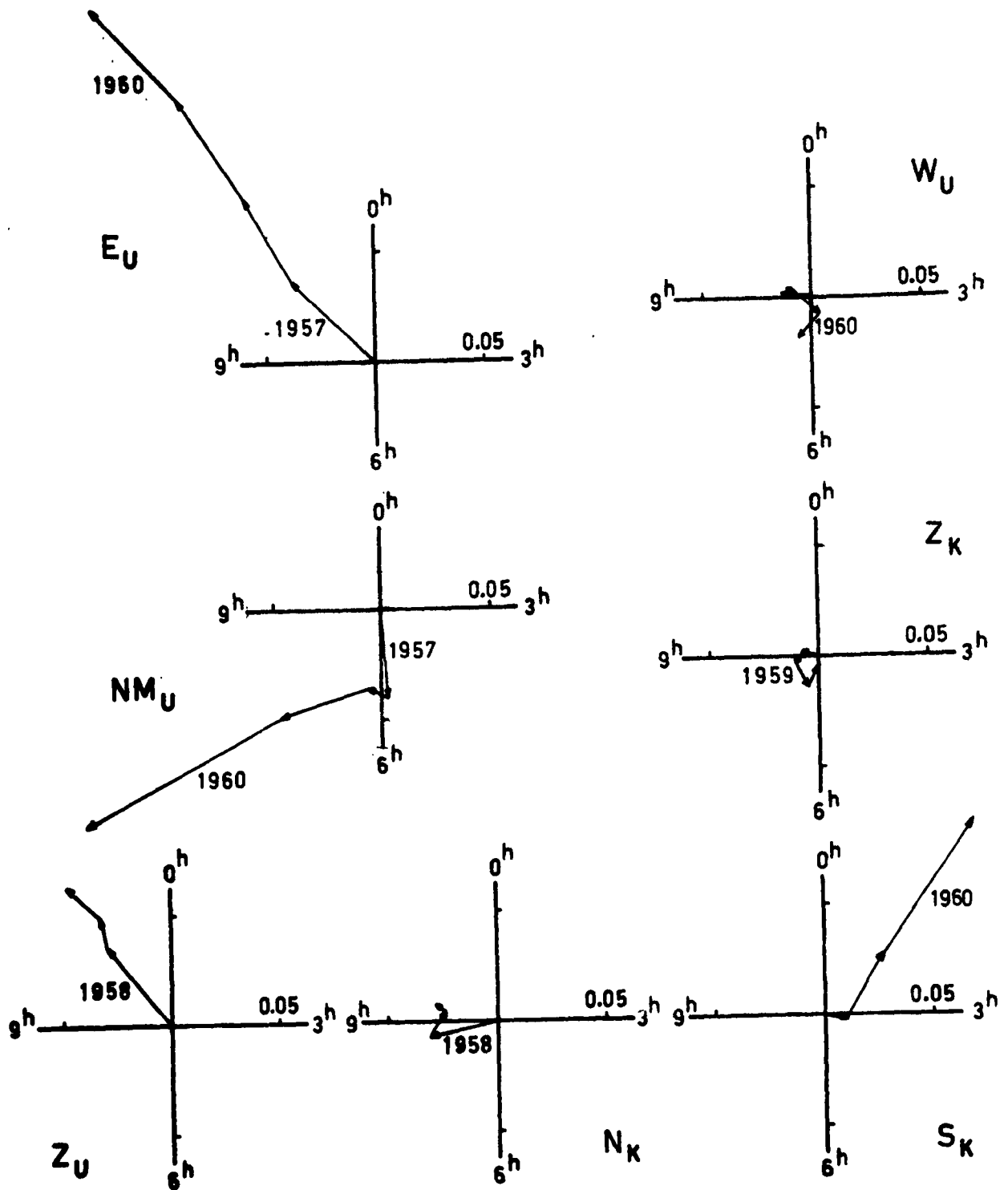


Fig. 3. Vector sum diagrams for the yearly means of the second harmonics.

5. The daily variation as a function of the K_p index.

The study of phase shifts and variations in the amplitude as a function of geomagnetic conditions follows the same lines as the identical studies in previous papers and technical notes (Sandström 1955; Sandström and Lindgren 1959; Techn. Note No 2; 12th Status Report; Sandström, Dyring, and Lindgren 1960). The days have been divided into classes according to their maximum K_p index. The classes are numbered I, II, III, IV, and V. They have been defined in all the references above. However, for convenience the definitions are repeated in Table 20. Only the first four classes are of practical interest (compare sec. 17, 12th Status Report).

Amplitudes and phases are to be found in Tables 21-24. No clock diagrams are being reproduced as all of them display the same characteristics as the corresponding diagrams in Figs. 10-11, Techn. Note No 2 and Figs. 30-31, 12th Status Report.

The fact that usually there is no appreciable phase shift between classes II and III makes it doubtful if the present rule for classifying the days according to their K_p indices is the right one. A special study is planned concerning this aspect.

Table 20

Class	Geomagnetic character figure
I	$[K_p]_{\max} \leq 1^+$
II	$1^+ < [K_p]_{\max} \leq 3^+$
III	$3^+ < [K_p]_{\max} \leq 5^+$
IV	$5^+ < [K_p]_{\max} \leq 7^+$

Remark concerning Tables 21-24: These tables differ slightly from the corresponding tables in 12th Status Report. In the latter each one of the tables contained the results from one recording instrument. In the present note all the amplitudes, resp. all the phases, from each one of the two stations are collected in one and the same table.

Table 21

UPPSALA. Mean amplitudes for days classified according to K_p index.

Calendar year 1960.

a) Standard error from Poisson distribution of primary value

b) Standard error from residuals after fitting 1st harmonic

c) Standard error from residuals after fitting 1st + 2nd harmonic

Instr. and dir.	Class of days	Number of days	First harm.	Second harm.	Standard error		
					a)	b)	c)
NM_U	I	10	0.554	0.134	0.057	0.121	0.128
	II	105	0.395	0.112	0.018	0.042	0.025
	III	156	0.306	0.113	0.015	0.042	0.024
	IV	55	0.466	0.054	0.025	0.050	0.053
Z_U	I	10	0.131	0.119	0.029	0.039	0.010
	II	107	0.168	0.024	0.009	0.010	0.007
	III	150	0.167	0.019	0.008	0.008	0.006
	IV	58	0.179	0.042	0.012	0.020	0.018
E_U	I	10	0.280	0.115	0.038	0.054	0.045
	II	106	0.226	0.059	0.012	0.021	0.011
	III	152	0.187	0.065	0.010	0.023	0.012
	IV	58	0.204	0.066	0.016	0.029	0.023
W_U	I	10	0.046	0.063	0.038	0.046	0.046
	II	103	0.095	0.010	0.012	0.011	0.012
	III	150	0.038	0.024	0.010	0.013	0.012
	IV	56	0.038	0.016	0.016	0.019	0.021

Table 22

UPPSALA. Mean phases for days classified according to K_p index.

Calendar year 1960.

a), b), c): See Table 21.

Instr. and dir.	Class of days	Number of days	First harmonic				Second harmonic		
			GMT	Stand. error in min.			GMT	Stand. error in min.	
				a)	b)	c)		a)	c)
NM_U	I	10	15 30	24	50	53	9 11	49	109
	II	105	13 33	10	24	15	8 24	18	26
	III	156	14 3	11	31	18	7 49	15	25
	IV	55	12 55	12	25	26	8 22	53	113
Z_U	I	10	16 0	67	88	22	9 48	28	9
	II	107	14 29	12	13	10	9 46	44	36
	III	150	14 46	10	11	8	10 4	46	36
	IV	58	13 40	16	26	22	11 52	33	47
E_U	I	10	15 28	31	44	37	9 25	38	45
	II	106	13 46	12	22	12	10 36	23	21
	III	152	13 42	12	29	14	10 36	17	20
	IV	58	11 31	18	33	26	10 31	28	43
W_U	I	10	17 35	187	227	231	6 41	68	84
	II	103	15 30	28	27	30	6 56	132	138
	III	150	16 18	59	77	70	7 38	46	56
	IV	56	15 37	96	115	125	10 55	112	147

Table 23

KIRUNA. Mean amplitudes for days classified according to K_p index.
Calendar year 1960.

- a) Standard error from Poisson distribution of primary value
b) Standard error from residuals after fitting 1st harmonic
c) Standard error from residuals after fitting 1st + 2nd harmonic

Instr. and dir.	Class of days	Number of days	First harm.	Second harm.	Standard error		
					a)	b)	c)
Z_K	I	8	0.131	0.042	0.029	0.042	0.045
	II	91	0.143	0.016	0.009	0.012	0.012
	III	141	0.102	0.011	0.007	0.014	0.015
	IV	50	0.078	0.025	0.012	0.018	0.018
N_K	I	10	0.050	0.024	0.036	0.036	0.040
	II	100	0.115	0.017	0.011	0.018	0.019
	III	146	0.115	0.023	0.009	0.010	0.007
	IV	51	0.106	0.019	0.016	0.015	0.015
S_K	I	9	0.087	0.108	0.038	0.042	0.028
	II	100	0.186	0.061	0.011	0.025	0.019
	III	143	0.200	0.083	0.009	0.032	0.019
	IV	49	0.111	0.069	0.016	0.029	0.021

Table 24

KIRUNA. Mean phases for days classified according to K_p index.
Calendar year 1960.

a), b), c): See Table 23.

Instr. and dir.	Class of days	Number of days	First harmonic						
			GMT	Stand.error in min.			GMT	Stand.error in min.	
				a)	b)	c)		a)	c)
Z_K	I	8	16 11	51	74	80	4 13	79	125
	II	91	15 52	14	19	20	1 46	62	89
	III	141	17 8	15	32	35	9 34	70	160
	IV	50	14 47	35	53	54	11 24	54	83
N_K	I	10	13 15	163	167	186	6 32	170	194
	II	100	13 18	22	36	39	0 8	76	131
	III	146	13 28	19	19	13	8 58	46	33
	IV	51	12 22	34	32	33	1 59	97	92
S_K	I	9	16 20	100	111	73	1 19	40	29
	II	100	17 42	14	31	23	1 27	21	35
	III	143	17 36	11	36	22	1 51	13	27
	IV	49	16 16	33	59	43	2 29	27	34

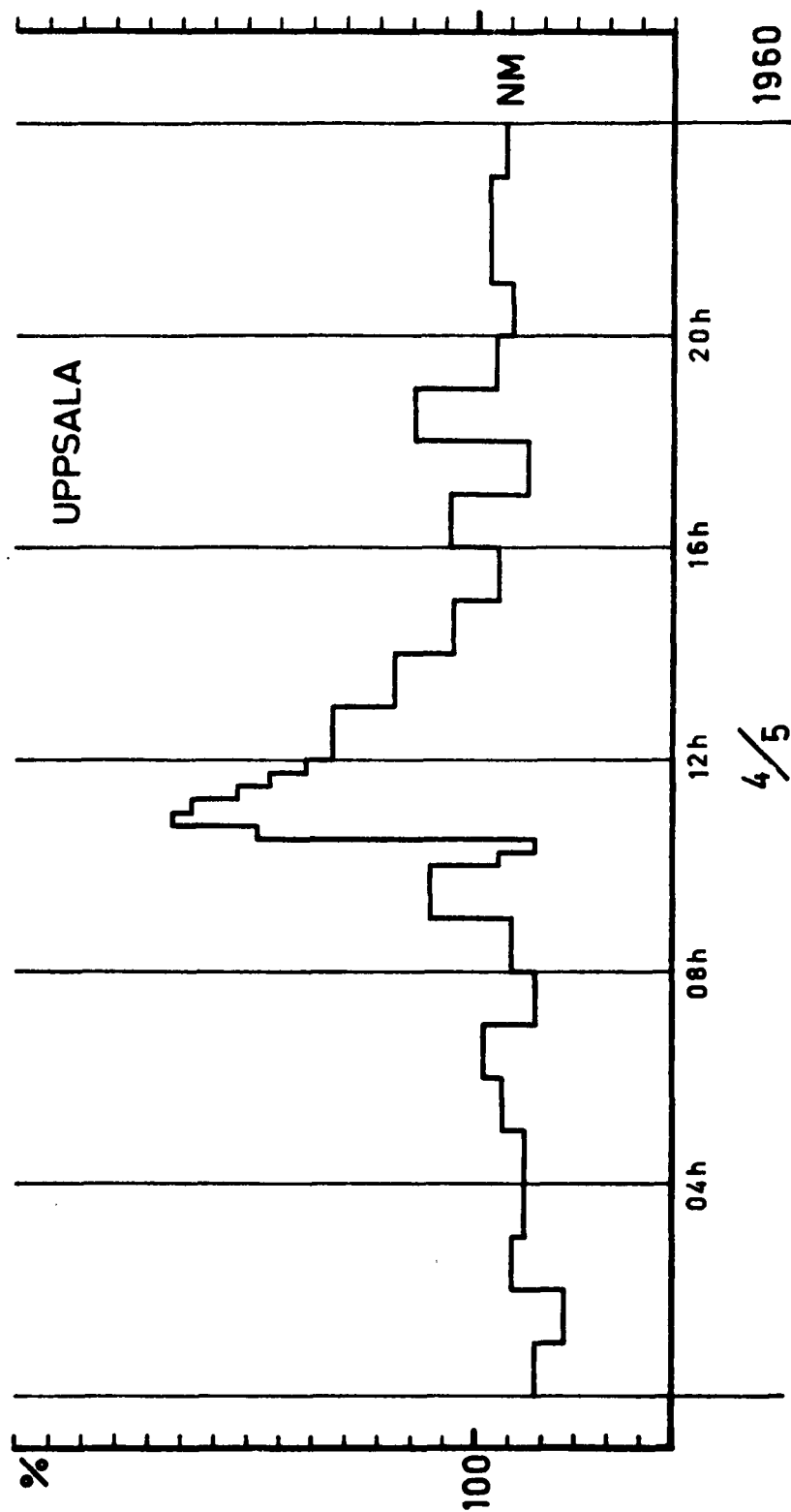


Fig.4. Quarter-hourly (and hourly) diagram for the period of the solar flare effect in May 1960.

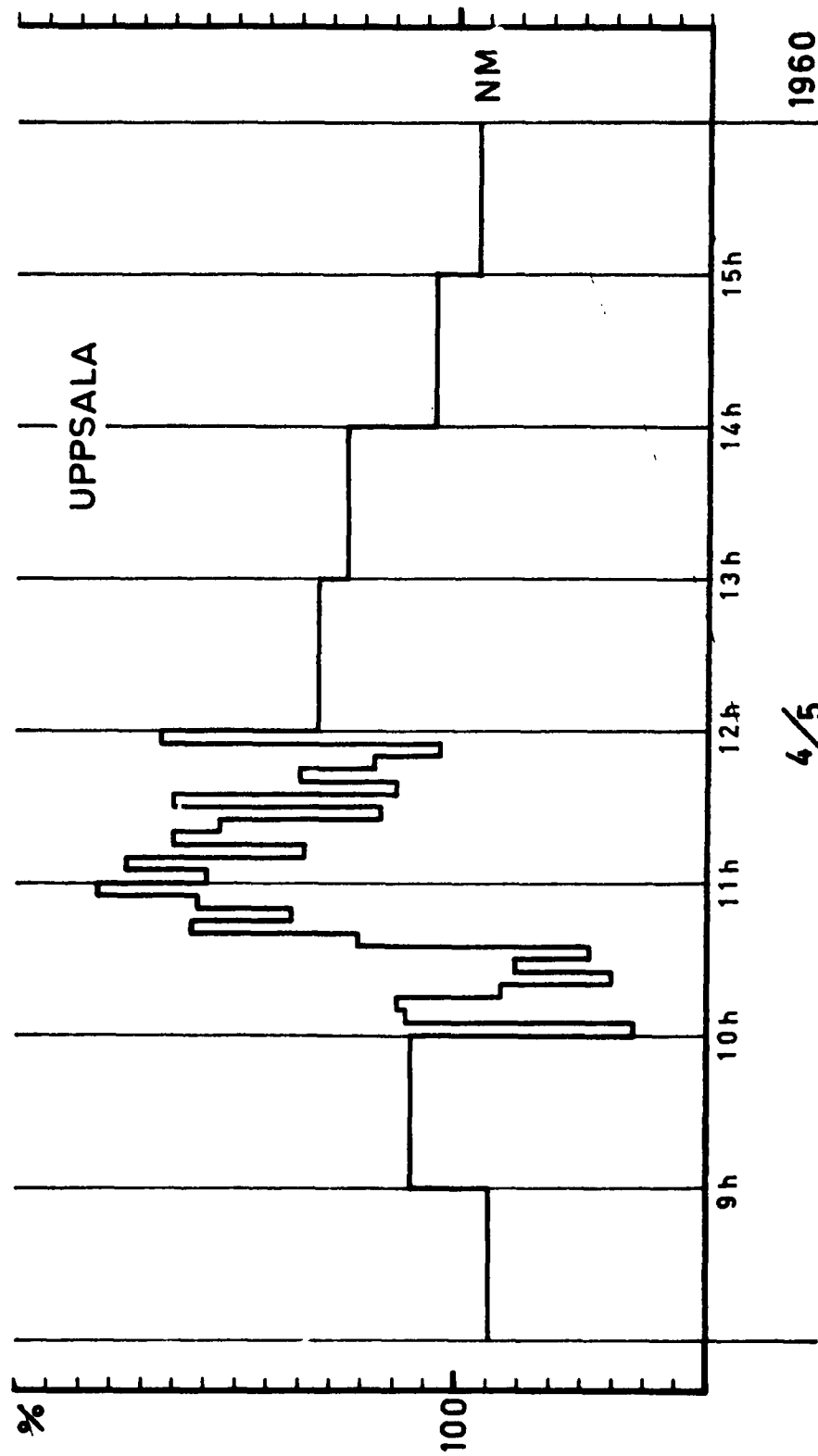


Fig.5. 5-minute (and hourly) diagram for the period of the solar flare effect in May 1960.

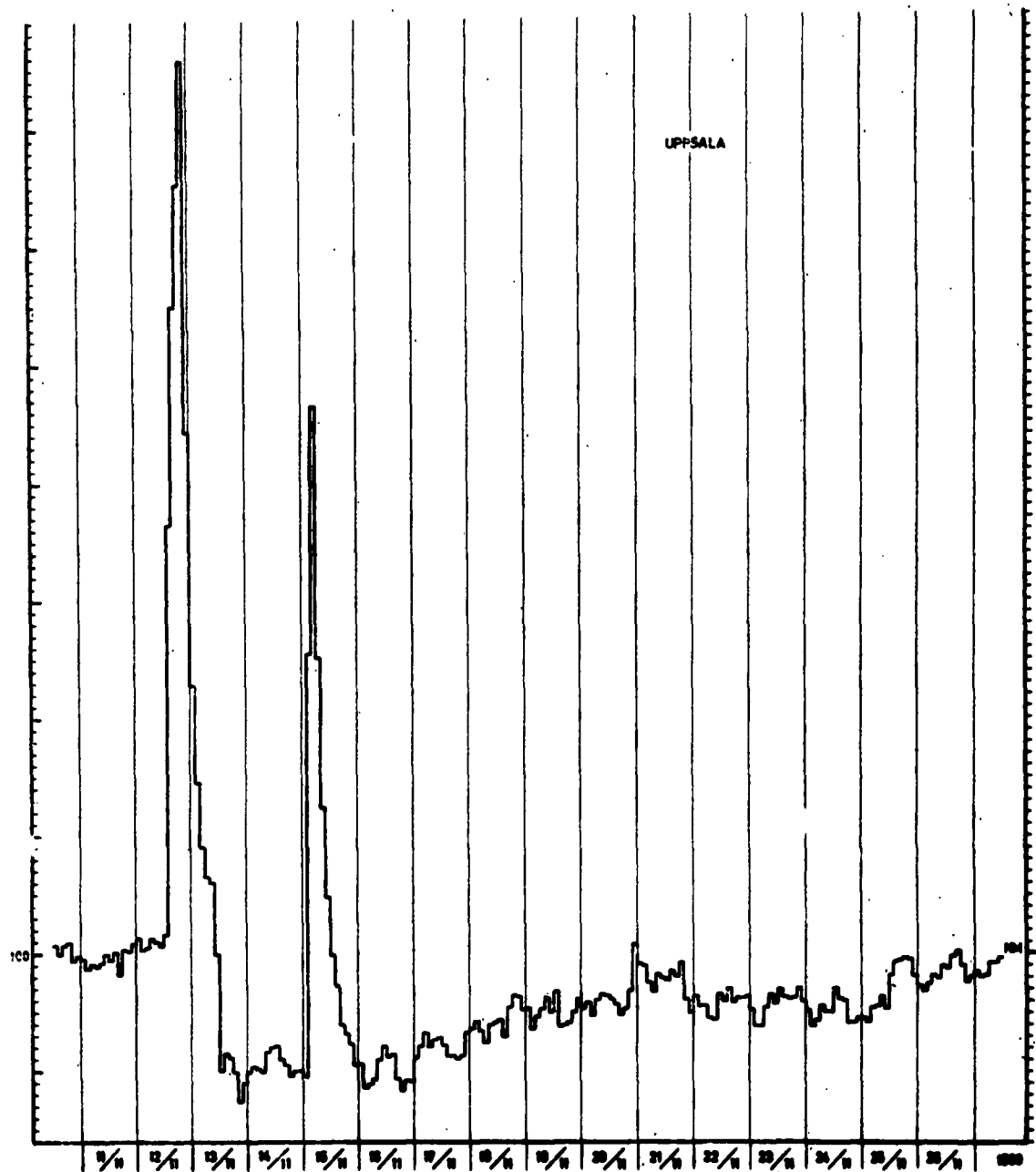


Fig. 6 Bihourly diagram of the singular events during the period
12 Nov. to 21 Nov. 1960.

6. Solar flare effects

During 1960 four solar flare effects were observed in the records of the nucleon component. None of them could be traced in the records of the meson component.

The first one of the four solar flare effects happened on May 4. In the 5-minute records the maximum intensity was only 11 per cent above the normal level for the preceding day. In the quarter hour records it was approximately 8 per cent. In the bihourly diagrams it is less than 6 per cent. It took place near the end of a C.R.S. (compare Fig. A 123). The quarter-hourly and 5-minute diagrams for the most interesting part of this flare effect are reproduced in Figs. 4 and 5. The onset time was $(10 \text{ h } 36.5 \text{ m} \pm 5 \text{ m})$ GMT

The other three solar flare effects took place on Nov. 12, Nov. 15, and Nov. 20. They are being made the subject of a separate techn. note (Technical Note No 9). A bihourly diagram is to be found in Fig. 6. A rough hourly diagram of the flare effects Nov. 11 and 15 is reproduced on the cover of the present note. The very small flare on Nov. 20 was identified only after the receipt of a report from Sulphur Mountain. It takes place immediately before a small F.d. on Nov. 21 (compare Fig. A 134).

7. The Forbush decreases

The bihourly diagrams of Forbush decreases and C.R. storms, presented here, are a direct continuation of the series of diagrams starting with Technical Note No 4. This series of diagrams is marked A. Those included into the present note are numbered A 118 - A 139. As the values are presented in the shape of histograms the time corresponding to each bihourly mean is easily found by means of the lines drawn for 00 GMT. The instruments and the directions of their axes are indicated by the letters to the right of each curve. When necessary the station (Uppsala or Kiruna) is indicated by an index. For complete explanations the reader is referred to Table 1, Technical Note No 4.

The bihourly values have been calculated in per cent of the mean intensity during a period preceding the decreases. These periods are listed in Table 25 together with the numbers of the corresponding diagrams. In some instances recording failures necessitated a departure from the rule of a common reference period for the diagrams of one and the same C.R.S. Every departure from the rule is listed in Table 27. In each case a reference has also been inserted in the "Remarks" column of Table 25.

The statistical fluctuations (assuming a Poisson distribution) are to be found in Table 1, Technical Note No 4. It ought to be remembered, however, that generally the true standard error is bigger than that calculated from an assumed Poisson distribution (E. Dyring, Technical Note No 6). When one or two channels have been out of order the accuracy is diminished by a corresponding factor. Such cases are listed in Table 26. Single bihourly periods have not been included. As compared to Table 3 in Techn. Note No 4, a rearrangement has taken place. In Table 26 the number of channels in use is given in column three as a quotient of the normal number. This change is partly due to the fact that a third channel has been added to the set of standard cubical telescopes in Kiruna. Accordingly, when channels have broken down four quotients are possible, $2/3$ and $1/3$ (cubical telescopes), $3/4$ and $2/4$ (directional telescopes). Before the change took place only three quotients were possible; $1/2$, $3/4$, and $2/4$, one single channel of the directional telescopes never being accepted for the records. π)

π) In Table 3, Techn. Note No 4, the second column has been falsely labeled. It lists the periods when only Three fourths of the normal number of channels have supplied the bihourly values.

When a change is known to have taken place in the normal counting rate of the recording instrument, this is marked in the diagrams by means of a thick vertical line and a star.

During 1960 most of the decreases were either very small or of short duration. In many cases the small ones cannot be traced in the records of the meson component. In other cases they can be traced in the latter only by comparison with the neutron monitor records. However, when available the meson records have been included in the bihourly diagrams even in cases when the decrease cannot be distinguished properly from the daily variations or the statistical fluctuations. They are included merely for the sake of facilitating comparisons.

Table 25

Period	Remarks	100 per cent equals mean value for:	Fig. number
<u>1960</u>			
12/1 - 20/1	Tab. 27	11, 12/1	A 118
30/3 - 8/4		29, 30/3	A 119, A 120
28/4 - 4/5		28, 29/4	A 121
7/5 - 17/5	Tab. 27	6, 7/5	A 122, A 123
21/5 - 26/5		20, 21/5	A 124
27/5 - 1/6		12 h 27/5 - 12 h 28/5	A 125
4/6 - 8/6	Tab. 27	12 h 3/6 - 12 h 4/6	A 126
26/6 - 1/7		00 h 26/6 - 12 h 27/6	A 127
13/7 - 18/7		12, 13/7	A 128
13/8 - 17/8	Tab. 27	12, 13/8	A 129
28/8 - 7/9		00 h 26/8 - 12 h 28/8	A 130, A 131
3/10 - 8/10		1, 2/10	A 132
10/11 - 26/11	Tab. 27	10, 11/11	A 133, A 134, A 135
30/11 - 2/12		28, 29/11	A 136, A 137, A 138
25/12 - 29/12		23, 24/12	A 139

Table 26

Fig. No.	Period with reduced number of channels	Channels in use/Total number
A 118	NM _U : 12d 00h - 20d 24h Z _U : 12d 06h - 16d 12h E _U : 12d 06h - 13d 18h 16d 10h - 24h 17d 10h - 24h 18d 10h - 19d 10h W _U : 12d 08h - 24h 16d 10h - 19d 10h Z _K : 18d 06h - 16h S _K : 13d 20h - 14d 10h	1 / 2 1 / 2 3 / 4 3 / 4 3 / 4 3 / 4 2 / 4 3 / 4 1 / 2 2 / 4
A 121	NM _U : 28d 00h - 06h 29d 00h - 12h 30d 02h - 14h 01d 00h - 08h 01d 22h - 02d 04h 02d 22h - 03d 06h N _K : 29d 16h - 30d 10h	1 / 2 1 / 2 1 / 2 1 / 2 1 / 2 1 / 2 2 / 4
A 120	N _K : 03d 14h - 04d 10h 05d 22h - 06d 06h	2 / 4 3 / 4
A 119	NM _U : 03d 06h - 16h Z _U : 07d 00h - 06h W _U : 03d 10h - 24h	1 / 2 1 / 2 2 / 4
A 122	NM _U : 15d 08h - 17d 24h Z _U : 12d 18h - 24h W _U : 10d 14h - 24h 14d 12h - 24h	1 / 2 1 / 2 3 / 4 3 / 4
A 123	Z _K : 16d 08h - 16h	1 / 2
A 124	NM _U : 24d 02h - 08h W _U : 01d 10h - 24h	1 / 2 3 / 4
A 125	NM _U : 27d 22h - 28d 06h 29d 22h - 30d 04h 01d 16h - 01d 06h E _U : 27d 12h - 24h	1 / 2 1 / 2 1 / 2 3 / 4

Continued overleaf

Table 26 continued

Fig. No.	Period with reduced number of channels	Channels in use/Total number
A 126	N_{M_U} : 04d 00h - 08d 24h W_U : 05d 02h - 20h 06d 02h - 16h Z_K : 08d 06h - 20h	1 / 2 2 / 4 3 / 4 1 / 2
A 127	N_{M_U} : 27d 16h - 28d 08h W_U : 28d 10h - 24h Z_K : 26d 08h - 27d 10h 27d 18h - 30d 10h 01d 06h - 24h N_K : 27d 16h - 28d 08h 29d 08h - 01d 06h S_K : 26d 10h - 22h 30d 12h - 20h	1 / 2 2 / 4 1 / 3 2 / 3 2 / 3 3 / 4 3 / 4 3 / 4 2 / 4
A 128	Z_U : 13d 02h - 10h E_U : 13d 02h - 10h Z_K : 13d 08h - 22h N_K : 14d 10h - 20h S_K : 14d 10h - 20h	1 / 2 2 / 4 2 / 3 3 / 4 3 / 4
A 129	N_K : 14d 00h - 10h 16d 22h - 17d 24h	3 / 4 3 / 4
A 130	N_{M_U} : 01d 00h - 18h Z_K : 31d 08h - 24h 02d 12h - 24h N_K : 29d 12h - 16h 01d 06h - 02d 08h S_K : 28d 08h - 29d 08h	1 / 2 1 / 3 2 / 3 2 / 4 2 / 4 3 / 4
A 131	N_{M_U} : 04d 10h - 16h 05d 06h - 06d 20h	1 / 2 1 / 2
A 132	S_K : 03d 00h - 08h	3 / 4
A 133	N_{M_U} : 10d 00h - 10h 10d 22h - 11d 14h	1 / 2 1 / 2

Continued overleaf

Table 26 continued

Fig. No	Period with reduced number of channels	Channels in use / Total number
A 137	Z _K : 11d 00h - 10h	1 / 3
	18d 04h - 22h	2 / 3
	N _K : 15d 14h - 16d 10h	3 / 4
	18d 08h - 18h	3 / 4
	S _K : 10d 14h - 11d 08h	3 / 4
	12d 18h - 24h	3 / 4
A 139	17d 08h - 18d 08h	3 / 4
	Z _K : 25d 10h - 20h	2 / 3
	25d 20h - 24h	1 / 3
	26d 00h - 10h	2 / 3
	26d 10h - 16h	1 / 3
	26d 16h - 24h	2 / 3
	29d 06h - 16h	1 / 3
	N _K : 30d 22h - 01d 10h	2 / 4
	25d 08h - 20h	2 / 4
	26d 06h - 22h	3 / 4
	27d 08h - 14h	3 / 4
	S _K : 30d 00h - 01d 10h	3 / 4
	25d 06h - 29d 10h	2 / 4

Table 27

Remarks to Table 25 and the diagrams.

Fig. No	Remarks
A 118	Reference level of W _U determined only by 12/1
A 124	Reference level for Z _U determined only by 21/5
A 125	Reference level of W _U determined only by 00h - 12 h 28/5
A 126	June 05d 00h a third channel was added to the standard cubical telescopes. The reference level for the remainder of the period was adjusted to the original level by means of the quotient between the channels.
A 128	One of the channels of the cubical telescopes changed its counting rate on July 7. It was excluded to the end of that day. The reference level for the rest of the period has been adjusted so as to fit the original level before the change took place.
A 133-134 A 135-136 A 137-138	These diagrams have been drawn so as to make it possible to cut out the second one and join it to the first one.
A 137	Concerning Z _K a change in counting rate took place on Nov. 10. By mistake the reference level was calculated from the bihourly means of both days (Nov. 10 and 11). If only Nov. 11 is employed 0.5 per cent should be subtracted from the bihourly values starting at 00h on the 11th.

8. Remark to 12th Status Report.

Tables 5 - 34: The sun rotation periods 1711 and 1712 display remarkable variations as to phase. This has been found to be due to an unusually big influence from the Forbush decreases during these periods. However, the removal of days with a F.d. has an effect which varies from one direction to another. The time of maximum will move towards later hours with amounts varying between half an hour and two hours.

The investigation is still incomplete as regards the shifts of phase and amplitude during short periods.

9. References.

Brunberg, E.Å., 1956: Cosmic Rays in the Terrestrial Magnetic Dipole Field, Tellus 8, p. 215.

Sandström, A.E., 1955: On the Correlation between Geomagnetic Activity and the Diurnal Variation of Cosmic Rays, Tellus 7, p. 204.

Sandström, A.E., Dyring, E., and Lindgren, S., 1960: The Daily Variation of the Cosmic Ray Nucleonic Component at Murchison Bay and Uppsala, Tellus 12, p. 332.

Sandström, A.E., and Lindgren, S., 1959: First and second harmonics of the daily variation of the cosmic ray nucleonic component at Uppsala Aug. 31, 1956 to Aug. 31, 1957. Ark.Fys. 16, p. 137.

Errata

12th Status Report Part I:

Tables 47 and 48 (p.75 and 76) The figures for Murchison Bay, WEST are wrong as concerns the period of 303 days extending from 1 Sep.1957 to 31 Aug.1958. The first harmonic has an amplitude of 0.009 per cent and the time of maximum at 13.10 GMT.

12th Status Report Part II:

Fig.6 Vector A in the harmonic dial for Murchison Bay, WEST is wrong. It should point in the 13.10-direction and have an amplitude of 0.009 per cent.

Fig.13 The diagrams refer to Uppsala (not to Murchison Bay).

Fig.20 gives second harmonics as can be seen from the time markings of the axes.

Technical Note No. 4, Table 3:

The second column is falsely labeled. It should read: Three fourths of the normal number of channels.

